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A cost effective paper pulp with fly ash coarse aggregate for concrete structure

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Abstract
The present scenario gives a lot of review that is made on artificial aggregates from various waste materials. In increasing industrial sector, a separate scheme is to be adopted for waste disposal. The industrial byproducts is not only the pollution caused but is also an environmental issue in the form of pollution and shortage of land to fill these materials. There are lot of researches that are under taken by different bodies to make some useful by products from the industrial waste for different applications. On the other side, shortage of natural aggregates in the growing infrastructure industry, creates problem of depleting natural resources which builds the need for artificial aggregates. In this aspect the identification and preparation of artificial aggregates for various applications leads to conserves environment from pollution and prevents natural resource from depletion, thereby giving way to sustainable development (1,2). This paper deals with identifying a suitable coarse aggregate for the concrete structure which is a challenging task to cut down the cost of construction in the field of civil engineering. In order to achieve economy and for effective utilization some of the waste materials such as paper pulp, steel slag, rice husk, e-beads, fly ash, etc., are suggested (3,4). The artificial aggregate is made out of waste materials such as paper pulp and fly ash in addition to clay and made as light weight course aggregate of size 20mm. The artificial aggregates thus prepared are heated in muffle furnace to about 1000 degree partially, added with natural coarse aggregates and made as concrete using self-compacting and self-curing materials.

Keywords: industrial waste, concrete structure, light weight, paper pulp, fly ash, coarse aggregate, artificial aggregate

1. Introduction
The major issue in the field of civil engineering is sustainable development and environmental impact due to increasing demand for natural resources. The main aim is to protect the natural resources for the future generation for their sustainment. With the developing infrastructure and by using a lot of natural resource leads to a big demand of natural aggregates. The sustainable development in the recent years of construction, demands the need of light weight structural design. The light weight aggregate posses less density, provide better insulation, cost effective and are suitable to produce light weight concrete. In this paper the aggregate is made using paper pulp, fly ash and marine clay. Paper pulp is an industrial byproduct obtained from the paper manufacturing industry [5, 7]. Fly ash from burning power plant is used in concrete primarily because of its pozzolanic and cementitious properties. These properties contribute to strength gain and improved durability when used with Portland cement. This can be used as aggregate in concrete in addition to clay and admixtures. This decreases the surface density, the cost of concrete and reduces the amount of natural aggregates used in concrete.

2. Artificial Aggregates
The sludge (paper pulp) is mixed with clay at various compositions (250 g of clay, 750 g of paper pulp,10 g of boric acid),(500g of clay,500 g of paper pulp,10 g of boric acid),(750g of clay,250 g of paper pulp,10g of boric acid) and made as a paste and is shaped into round pellets to be used as coarse aggregate.

Fig 1: Sludge mix with clay and paste

Fig 2: Round pellet Coarse Aggregate

The pellets are then subjected to a high temperature muffle furnace where it is heated up to 1000^0C.Then the results are to be checked for finding the density of the aggregates with the addition of boric acid and the increase in firing temperature

3. Coarse aggregates testing methods
3.1 Abrasion Test
The test sample of clean aggregates dried in an oven to about 105^0C to110^0C with a substantially constant weight. The test sample and the abrasive charge is placed in the Los Angles abrasion testing machine and the machine is rotated at a speed

of 20 to 33 revolutions/minute for 1000 revolutions. At the end of the test, the material is discharged and sieved through 1.70mm ISSieve.

3.2 Impact Test
The test sample of aggregates is passed through 12.5mm sieve, are retained on 10mm Sieve and dried in an oven for 4 hours at a temperature up to 1000^0C. The aggregate is filled to about 1/3 of a cylinder measured and tamped 25 times using the rounded end of the tamping rod. The rest of the cylinder is filled by two layers and each layer is tamped 25 times to from a straight edge with a weight approximately to 0.01gm.This is then carefully transferred into the cup which is firmly fixed in position on the base plate of machine and tamped 25 times. The hammer is raised until its lower face is 38cm above the upper surface of aggregate in the cup and allowed to fall freely on the aggregates. The test sample is subjected to a total of 15 such blows each being delivered at an interval of not less than one second to obtain a crushed aggregate.

3.3 Specific Gravity
Specific gravity of soil solids is the ratio of weight in air of a given volume of dry soil solids to the weight of equal volume of water at 4ºC.Specific gravity of soil grains gives the property of the formation of soil mass and is independent of particle size. Specific gravity of soil grains is used in calculating void ratio, porosity and degree of saturation, by knowing moisture content and density. The value of specific gravity helps in identifying and classifying the soil type.

3.4 Compressive Test
It is determined by a comparison test on specially produced specimens. The main factors that influence this test are the type of cement, the W/C ratio and the degree of hydration which is affected by the curing time and method. Tests are done at recognized ages of the test specimens, usually being 7 days. The ages should be calculated from the time of the addition of water to the drying of ingredients. The specimens are prepared according to IS: 516 - 1959 and stored in water, should be tested immediately on removal from the water and when still in wet condition. Specimens when received dry should be kept in water for 24hrs before they are taken for testing. The dimensions of the specimens, to the nearest 0.2mm and their weight are observed before testing. The bearing surfaces of the compression testing machine should be wiped clean and any loose sand or other material is removed from the surfaces of the specimen, which would be in contact with the compression platens. The cubical specimen for the test is kept in a position that the load could be applied to the opposite sides of the cubes and not to the top and bottom.
The axis of the specimen should be carefully aligned with the centre of thrust of the spherically seated platen. Packing is avoided between the face of the test specimen and the steel platen of the testing machine. As the spherically seated block is brought to rest on the specimen, the movable portion is rotated gently by hand for uniform seating.
The load is applied without shock and increased continuously at a rate of approximately 140kg/sq.cm/minute until the resistance of the specimen to the increasing load breaks down and no greater load is sustained. The maximum load applied to the specimen is then be recorded. The appearance of the concrete and any unusual features in the type of failure is to be observed.

4. Result Analysis
4.1 Absorption Test
The proportion of loss between weight 'A' and weight 'B' of the test sample should be expressed as a percentage of the original weight of the test sample. This value is reported as,
A – B and aggregate abrasion value in percentage is calculated by multiplying with 100.

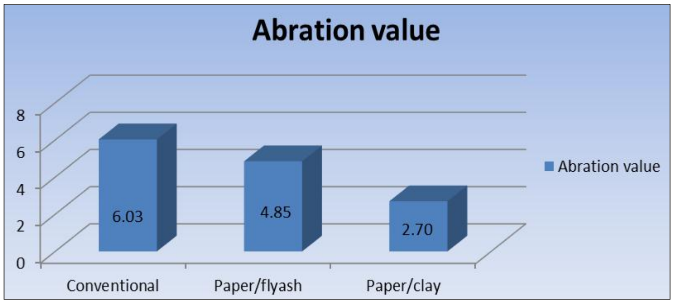

Fig 3: Abrasion test chart

4.2 Impact Test
The crushed aggregate is removed from the cup and the whole of it is sieved on 2.366mm sieve until no significant amount passes. The fraction passing the sieve is weighed accurate to 0.1gm. Repeat the above steps with other fresh sample the original weight of the oven dry sample is W1gm and the weight of fraction passing 2.36mm IS sieve be W2gm. Then aggregate impact value is expressed as the % of fines formed in terms of the total weight of the sample. The calculation is provided below:

Total weight of aggregate sample filling the cylinder measure	=W1 g
Weight of aggregate passing 2.36 mm sieve after the test	=W2 g
Weight of aggregate retained 2.36 mm sieve after the test	=W3 g

(W1-W2+W3)

Aggregate impact value = (W2/W1)*100 percent

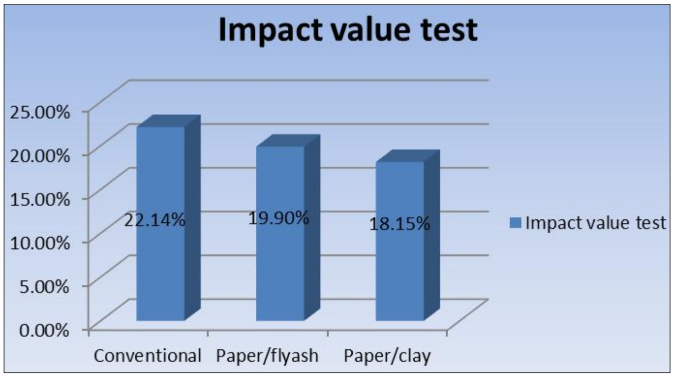

Fig 4: Impact test Values

4.3 Specific Gravity Test

A dried pycnometer is weighed with its cap (W1). 200gm of oven dried soil is passed through 4.75mm sieve into the pycnometer and weighed again (W2). Sufficient de-aired water is added to cover the soil and is screwed with the cap. The pycnometer is well shaked to remove entrapped air and filled it with water. The pycnometer is dried from outside and weigh it (W3). Weigh the pycnometer after drying it on the outside thoroughly (W4). Repeat the procedure for three samples and obtain the average value of specific gravity. The calculation is provided below:

Determine the specific gravity of soil grains (G) using the following equation

$$G = \frac{W2 - W1}{(W2 - W1) - (W3 - W4)}$$

Where,
W1 = Empty weight of pycnometer.
W2 = Weight of pycnometer + oven dry soil
W3 = Weight of pycnometer + oven dry soil+ water
W4 = Weight of pycnometer + water

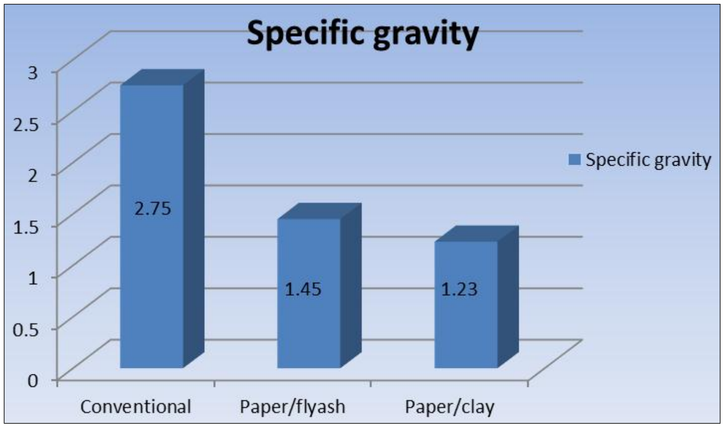

Fig 5: Specific gravity chart

4.4 Compressive Test

The measured compressive strength of the specimen is calculated by dividing the maximum load applied to the specimen during the test by the cross - sectional area, calculated from the mean dimensions of the section and is expressed to the nearest kg/sq.cm. An average of three values is taken as the representative of the batch, provided the individual variation is not more than 15% of the average. If not the test is repeated and the results are observed as shown in table.1. The product of the correction factor and the measured compressive strength is known as the corrected compressive strength, this being the equivalent strength of a cylinder having a Height/diameter ratio of two. The equivalent cube strength of the concrete is determined by multiplying the corrected cylinder strength by 1.25

Table 1: Comparison of compressive strength

	Compressive Strength of conventional Concrete after 7 Days	**Compressive Strength of Concrete Using Coarse Aggregate after 7 days (Paper pulp/Fly ash)**	**Compressive Strength of Concrete Using Coarse Aggregate after 7 days (Paper pulp/ clay)**
7 days Curing	11.2	7.8	9.2
	11.4	7.9	9.4
	11.5	7.84	9.1

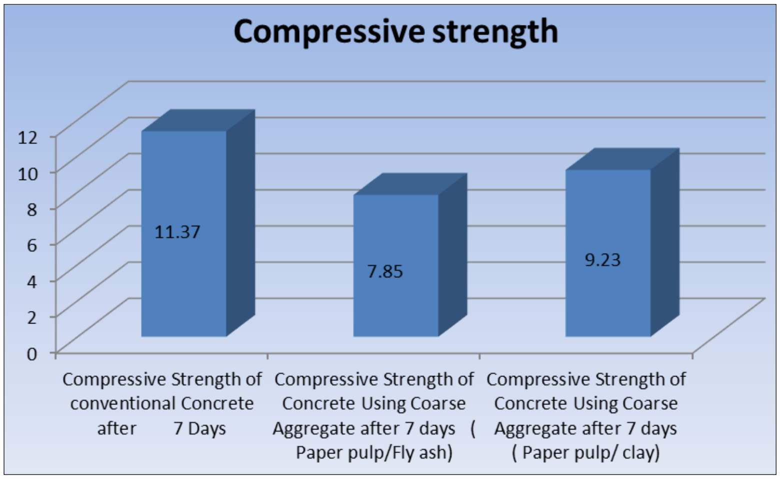

Fig 6: Compressive strength chart

4.5 Cost Analysis

Comparison of Cost of both Conventional Concrete and Artificial aggregate is observed as shown in table.2.Concrete for One Cube (.15m x .15m x.15m).

Table 2: Cost Analysis

Properties		Conventional Concrete		Artificial Aggregate Concrete			
				50:50		50:50	
Sl.no	Material	Quantity	Rate	Quantity	Rate	Quantity	Rate
1	Cement	2.5Kg	Rs22	2.5Kg	Rs22	2.5Kg	Rs22
2	Fine Aggregate	5Kg	Rs15	3.56Kg	Rs10	3.56Kg	Rs10
3	Coarse Aggregate	7Kg	Rs25	4.32Kg	Rs15	4.32Kg	Rs19
4		Total	Rs62	Total	Rs47	Total	Rs 51

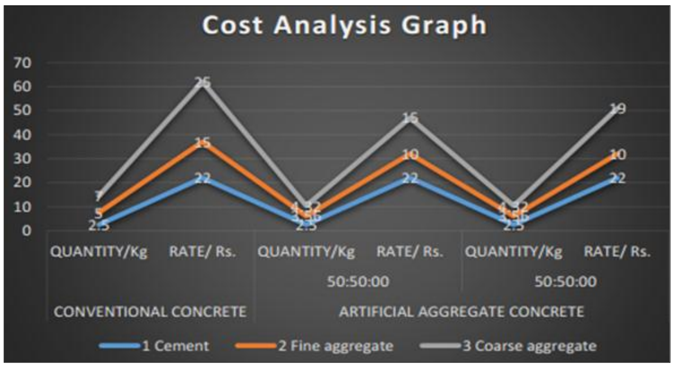

Fig 7: Cost Analysis Graph

The above table compares the cost of conventional concrete and artificial aggregate Concrete for a cube. From comparison it is found that the concrete from 50:50 Coarse aggregate is cost efficient. When compared conventional Concrete i.e. nearly 25% of cost saved when using the coarse aggregate concrete as shown in fig.7

5. Conclusion

The following conclusions are made from the above test and with the analysis of the result obtained. The physical properties of the Coarse Aggregate which were prepared artificially have the required strength for construction. The compressive strength of the Coarse Aggregate concrete has surpassed the minimum strength that a SCC3 concrete must have. From above comparison and result it observed that the conventional aggregate can be successfully replaced by Coarse Aggregate concrete. When comparing both paper pulp/ fly ash, paper pulp/clay can be used successfully to replace conventional aggregate. But paper pulp/ fly ash concrete is recommended because of its high compressive strength. The aggregates are vital elements in concrete. Fly ash, paper pulp is also one of the hazardous environment pollutants which cannot be disposed. Hence it is suggested to use coarse aggregate made from fly ash, paper pulp in the future which also cost effective.

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